IRON AND STEEL STRUCTURES.

EFFECT OF

MAGNETIC AND GALVANIC FORCES

UPON THEM.

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THE EFFECT OF MAGNETIC AND GALVANIC FORCES UPON THE STRENGTH OF, AND DESTRUCTION OF IRON AND STEEL STRUCTURES.

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Bars and Structures of Iron and Steel when allowed to remain at rest for a considerable time acquire measurable magnetic polarity.

Moderate percussion, alternations of heat and cold, exposure to the rays of the sun, especially with a long axis of figure parallel, or nearly coincident with a magnetic meridian of the earth have a tendency to develop and strengthen magnetic polarity.

Thus, Iron Bridges, Iron Vessels upon the stocks in progress of construction, and Iron Railway Tracks are particularly liable to acquire magnetic polarity.

It is asserted that the relative position of the long axis of Iron Ships with reference to the magnetic meridian materially affects their polarity and the facility of the correction of their compasses.

If the keels of such vessels be laid on a North and South line, they are supposed to acquire greater polarity, and to retain it more steadily than when laid East and West.

The evidence of an iron ship's polarity is exhibited to the greatest degree, by comparison of its effects upon its compasses when the vessel is sailing in an easterly or westerly direction.

A consideration of the following facts seems to favor the conclusion that magnetic bars of Iron should be better able to resist tensile strain than those which are not magnetic.

A thoroughly magnetic bar is one of which each end repels a pole of a magnetic needle. The centre of such a bar is neutral, that is attracts either end of a magnetic needle and repels neither.

If we break such a bar in half, we are possessed of two magnetic bars; that end of the original bar which attracted the south end of a magnetic needle continues to attract it, that which attracted the north end continues to do so, whilst the two new ends which had formed the neutral centre of the original bar, each acquires a polarity opposite to ~~each~~ the other, and also opposite to that possessed by its own opposite end. A continuance of this process, that is, the fracturing of each half until we have obtained such minute fragments of the bar as can be examined only under the microscope, still produces perfectly polarized bars, possessing all of the magnetic characteristics of the original bar, with varying, attracting, and repelling force according to some ratio of the relative length and thickness of the fragments.

Arguing upon this we are led to the conclusion that a continuance of this process must produce molecular magnets.

If we place magnetic bars in contact with each other, the north and south poles alternating and in contact with each other we obtain a metallic

chain of considerable strength, although its component parts are not mechanically connected together. The closer the contact of the ends of the bars the stronger will be the chain.

If with isolated bars we can obtain a connecting force equal to many pounds by close contact, how much stronger must be the connecting force when exerted between molecule and molecule.

Such an argument undoubtedly leads to the conclusion that bars saturated with magnetic force should certainly be stronger than those that are not.

Faraday announced that "there existed lines of force within the magnet of the same *nature* as those without. What is more they are exactly equal in *amount* with those without. They have a relation in *direction* to those without; in fact are continuations of them, absolutely unchanged in their nature."

To determine the effect of magnetic force upon the tensile strength of Iron and Steel,* bars of each were selected and cut into suitable lengths for use in the breaking machine and numbered.

Nos. 1, 3, 5, &c., were broken in the usual manner.

Nos. 2, 4, 6, &c., whilst in the breaking machine were surrounded by a suitable coil of copper-wire, through which a current of galvanic electricity was passed during the operation of breaking.

The results obtained from the magnetic Steel bars were about one per cent. less than those obtained from the non-magnetic, and from the magnetic soft Iron bars about three per cent. less than from the non-magnetic.

Both the Steel and Iron bars became heated whilst within the influence of the current of electricity, the soft Iron more so than the Steel.

It occurred to me that the depreciation of strength might have been caused by the rise of temperature† in the bars, and I accordingly prepared permanent magnets from alternate sections of a steel bar and repeated the experiments comparing the cold magnets with the unmagnetized sections of the same bar. The results showed no appreciable difference in strength between the magnetic and non-magnetic sections.

To test the matter still further, bars of Steel were so magnetized as to present a pole at one end, the other in the middle of the bar, with one end neutral, that is, one end of the bar attracted the North or South pole of a magnetic needle and repelled the South or North, and the other end of the bar attracted either pole of a magnetic needle.

* The Steel employed in the experiment was "Jessop's Round Machinery," ½ inch rod—

and broke at { maximum, 127,934 lbs.; minimum, 125,694 lbs. }

per square inch of section.

The Iron broke at { maximum, 59,948 lbs.; minimum, 56,887 lbs. }

per square inch of section.

† For effects of temperature upon the tensile strength of Iron, see Report of the Committee [redacted] of the Franklin Institute of Pennsylvania,—"upon the strength of materials employed in the construction of Steam Boilers." Experiments made at the request of the Treasury Department of the United States (Jan'y 4th, 1831—Jan'y 5th, 1837).

Under these conditions if there was any effect to be had from the influence of the magnetic force, the bar should incline to break either at the central pole or at the neutral point between the poles.

The results of the experiments showed that there was no inclination to a choice of either location as the place of fracture.

The conclusion arrived at, is, that *the condition of magnetic polarity does not in any way influence the strength of steel bars.* With reference to the soft iron bars the comparison was not made, for the reason that they would not remain magnetic unless surrounded by the galvanic coil, in which case they became heated by the action of the current.

How far a change from fibrous to crystalline structure is effected by the influence of magnetism has not been ascertained, or whether there is any deterioration of the strength of iron or steel on such account.

Iron telegraph wires, in the course of time become brittle, and to such an extent that if the usual method of uniting them by winding each upon the other is attempted, they are frequently broken in the process.

From this it would appear that the passage of a strong galvanic current produces some molecular change affecting the strength of iron. Such conducting wires, however, are not necessarily or even usually magnetic. There can be no doubt, however, as to the deteriorating effect of *galvanic* force as an accelerator of oxidation or the solution of a metal.

Observations upon Iron Bridges and structures subjected to atmospheric influences and upon Boilers exposed to the action of heat and the chemical agents contained in ordinary waters lead to the conclusion that galvanic force is usually as great, and frequently a far greater cause of deterioration than mechanical wear. Indeeed all of the operations of nature, organic and inorganic, both constructive and disjunctive, involve the production of more or less galvanic force or are the results of its action.

Motion, unaccompanied by any other apparent change than that of place, is a disturber of electric or galvanic equilibrium, and the converse is equally true. If it were possible to produce perfectly pure and homogeneous iron, then the generation of destructive galvanic currents by the contact of sheets or bars would not take place.

By exercising care in the selection of iron, especially that used for steam boilers, the deterioration from galvanic action can be reduced to a minimum.

Many steam boilers have come under my observation in which the corrosion was but slight, and affected all parts equally, others in which the metal of a single sheet only was attacked, the corrosion of which sheet protected the remainder of the boiler almost as efficiently as if the sheet had been replaced by one of the metal zinc.

The most striking instance of the effect of introducing a sheet of metal of greatly differing electro-condition, that occurs to me, is that of a boiler which had been in use for a considerable length of time without showing any unusual tendency to corrosion, when from some cause it became necessary to replace a sheet by a new one.

The result of the introduction of a new sheet was to set up at once a strong galvanic action by which every sheet in the boiler was corroded except the new one.

Samples of iron cut from the edges of the old and from the new sheets were placed in a bath to which a few drops of dilute acid were added and a connection made with a galvanometer, resulting in the production of a strong current; the purer iron corroding, and protecting that which contained the greatest amount of carbon.

The inciting cause of the galvanic action was therefore judged to be the introduction of a sheet of iron electro-negative to those already in the boiler, its position in the electro-chemical scale depending upon the amount of carbon it contained.

The injurious effect consequent upon the junction of masses of wrought iron of varying electro-chemical properties, is, therefore, increased when *steel* is joined to wrought iron, as is frequently the case in locomotive boilers in the tubes and tube sheets.

Again by the junction of *cast iron* to steel or to wrought iron, the destructive effect is greatly intensified, and at times becomes quite as violent as when copper is made an element in the galvanic circuit in connection with wrought iron.

The necessity for the selection of iron with reference to its electric condition, applies equally to the material employed for Bridges or Vessels or Boilers or any structure which is to be built up from separate sheets and bars of iron.

It is or ought to be the habit of careful constructors to cut sample pieces from every sheet or bar of metal worked, and to make a trial of their quality by bending hot and cold, and to make frequent tests of tensile strength. Examinations as to electro-chemical condition can be made with equal facility. Determinations of the composition of the metal or of the percentage of carbon in it by chemical analysis are unnecessary; an ordinary workman furnished with a coarse galvanometer and a weak acid bath can ascertain the exact electro-condition of each sheet or bar more rapidly than he can examine the quality by the ordinary tests of bending on an anvil, hot and cold. With the metal of Bridges, Vessels, and especially Steam Boilers, the deterioration by corrosion is more to be feared than is mechanical wear.

Galvanic corrosion acts with greater vigor in locations that are usually inaccessible, such as the interior of joints or defective sheets or parts that are closely approximated, and the mischief is only suspected when it has progressed to such a degree as to become evidently dangerous and the parts are in condition to require immediate attention and repair.

Attention to the precautions enumerated for securing mechanical and chemical fitness of the metal to be used for structures of iron, will undoubtedly promote economy and safety.